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Indigenous Low Maintenance Externally Powered Elbow Unit for a Transhumeral Amputee

Prakash Sahoo[1], Shayantan Chowdhury[2], Tanmaya Kumar Pany[3], Dr Ameed Equebal[4], Dr Lalit Narayan [5]

[1]Demonstrator, NILD, Kolkata, India
[2]Internee BPO, NILD, Kolkata, India
[3]Demonstrator, NILD, Kolkata, India
[4]Asst.Director (T) cum Asst. Prof, NILD, Kolkata, India
[5]Director, NILD, Kolkata, India

Corresponding Author: Prakash Sahoo

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ABSTRACT

Transhumeral amputation often leads to a significant reduction in autonomy, impeding the ability to perform daily living, work, and social activities. While current prosthetic solutions have addressed this issue to some extent, limitations persist, particularly due to the high costs of upper-limb prosthetic components, which remain a significant barrier in low-income regions. One of the key challenges faced by transhumeral amputees is the selection of a prosthetic elbow joint that is both functional and affordable. Though there are electric elbow units available in the market, their high price makes them inaccessible to many, particularly in resource-constrained settings. This study aims to design and develop a low-maintenance, externally powered prosthetic elbow unit that is cost-effective for low-income populations. The proposed prosthesis is designed to facilitate Activities of Daily Living (ADL) by providing an affordable and functional alternative for transhumeral amputees. By addressing the need for an affordable prosthetic elbow, this study hopes to improve the quality of life and independence for individuals with transhumeral amputations in low-income regions.

Keywords: Transhumeral amputation, prosthetic elbow, low-cost prosthesis, low-income countries, activities of daily living, externally powered elbow unit

INTRODUCTION

Upper-extremity amputations, though less common than lower-limb amputations, still represent a significant challenge, with major upper-limb amputations accounting for only 8% of the 1.5 million individuals living with limb loss. [1] Trauma is the most common cause of acquired amputations in the upper limb, affecting men between the ages of 15 and 45. Amputations are categorized according to the joint level at which they are executed that is trans-phalangeal, trans-metacarpal, trans-carpal, wrist disarticulation, trans-radial, elbow disarticulation, trans-humeral, shoulder disarticulation, and forequarter amputation. [2]

The elbow joint plays a critical role in facilitating a wide range of Activities of Daily Living (ADLs), as it acts as a pivotal link between the shoulder and hand. Consequently, the absence of a functional elbow joint severely impacts an amputee's ability to use prosthesis effectively, limiting their independence and quality of life. [3,4]

While current prosthetic solutions, including prosthetic elbow joints, have provided some degree of functionality, significant limitations remain, particularly in terms of accessibility and cost. The high cost of upper-limb prosthetic components is a major barrier, especially in low-income regions where access to advanced prosthetics is minimal. Although there are electrically powered prosthetic elbow units available in the market, their prohibitive price renders them inaccessible to many amputees in resource-constrained settings.

This study aims to address these challenges by developing an Indigenous Low-Maintenance Externally Powered Elbow Unit specifically designed for transhumeral amputees in low-income areas. The primary objective is to create a prosthetic elbow that combines affordability, durability, and ease of maintenance to enable individuals with transhumeral amputations to perform ADLs effectively. By reducing the cost and maintenance burden associated with current prosthetic elbow an option, this research seeks to improve the quality of life and enhance the autonomy of amputees, particularly in regions where access to advanced prosthetics is limited.

MATERIALS & METHODS

A 45-year-old male with a right transhumeral amputation was selected as the subject for this study. Prior to this intervention, the amputee was using a body-powered prosthesis with a mechanical elbow joint, which was noted to be bulky and aesthetically unappealing. The user experienced several issues with the prosthesis, including difficulties with donning and doffing, as well as discomfort due to the weight of the device. These issues significantly hindered the amputee's ability to perform daily activities effectively and comfortably.

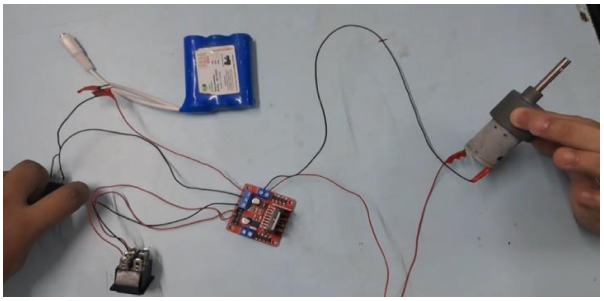
In response to these challenges, an Indigenous Low Maintenance Externally Powered Elbow Unit was fabricated and integrated into the prosthetic design. The new elbow unit was specifically designed to be operated by the contralateral sound side hand, providing the amputee with an intuitive and functional control mechanism. The externally powered elbow joint utilized a geared DC motor with a stall torque of approximately 7 kg-cm. This motor, in combination with a gear system, converts the rotational speed of 100 RPM from the motor to produce movement that closely mimics the natural anatomical motion of the elbow. By adjusting the gear ratio, the stall torque of the motor can be altered to optimize performance and meet the user's needs.

The prosthesis was fitted and evaluated for its functional performance, user satisfaction, and psychological well-being. The user's satisfaction with the prosthesis was measured using the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0) before and after the intervention to assess changes in overall satisfaction and mobility. Key factors such as ease of donning and doffing, weight distribution, comfort, and the ability to perform Activities of Daily Living (ADLs) were also evaluated.

Through this methodology, the aim was to create a prosthesis that addressed the limitations of the traditional body-powered device, while providing an affordable, low-maintenance solution that could enhance the amputee's independence and overall quality of life.

Indigenous Low Maintenance Externally Powered Elbow Unit

Lithium Ion Battery – 12 Volt



Functional Externally Powered Elbow Assembly Unit

DC Motor – 100 RPM

RESULT

The Indigenous Low Maintenance Externally Powered Elbow Unit was successfully developed and evaluated for its effectiveness in improving the mobility and psychological satisfaction of transhumeral amputees. A key evaluation tool used to assess user satisfaction was the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0).

Before the introduction of the new prosthetic elbow unit, participants using a body-powered elbow unit had an average pre-test satisfaction score of 4.7, which fell under the category of "more or less satisfied." After using the Indigenous externally powered elbow unit, the post-test score significantly improved to 8.7, reflecting a high level of satisfaction and moving closer to the "totally satisfied" category.

This substantial increase in satisfaction indicates that the developed prosthetic elbow unit not only met the functional requirements of the users but also contributed to enhanced psychological well-being by improving their ability to perform daily activities. The results highlight the positive impact of the low-maintenance, externally powered prosthesis in enhancing the overall quality of life and independence for transhumeral amputees.

DISCUSSION

The development of the Indigenous Low Maintenance Externally Powered Elbow Unit for transhumeral amputees addresses several key challenges faced by individuals in low-income regions: the high cost and complexity of prosthetic components, particularly the elbow joint. This study demonstrates that a functional and affordable prosthetic solution can be achieved by designing a low-maintenance, externally powered prosthetic elbow, and operated by the contralateral sound side hand. The results suggest that the developed elbow unit effectively improves both the functional performance and psychological satisfaction of users. [5-8]

One of the most significant outcomes of this study is the marked improvement in user satisfaction, as reflected in the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0). The substantial increase in the satisfaction score from 4.7 (more or less satisfied) to 8.7 (totally satisfied) indicates that the prosthesis not only met the user's functional needs but also had a positive impact on their overall well-being. The reduction in the weight and bulkiness of the prosthesis, as well as the improved ease of donning and doffing, were key factors contributing to the enhanced user experience. These factors, combined with the intuitive control mechanism provided by the sound-side hand, likely played a crucial role in improving the user's ability to perform Activities of Daily Living (ADLs).

From a functional perspective, the geared DC motor and adjustable gear system allowed the prosthetic elbow to closely mimic the natural anatomical motion of the elbow. This design ensured that the prosthesis could meet the user's needs for a

wide range of motions and activities, which is essential for maintaining independence and autonomy in daily life. The ability to modify the gear ratio to alter stall torque further enhanced the adaptability of the device, ensuring that it could be customized to suit the user's preferences and activities.

While the results are promising, it is important to note that the study was conducted with a single subject, limiting the generalizability of the findings. Future research with a larger sample size would be beneficial to validate the effectiveness and satisfaction levels of this prosthetic unit across a more diverse group of transhumeral amputees. Additionally, long-term studies would be valuable to assess the durability and maintenance needs of the prosthetic elbow in real-world conditions, particularly in resource-limited settings.

Despite these limitations, the success of the Indigenous Low Maintenance Externally Powered Elbow Unit in this study provides valuable insights into the development of affordable, functional, and user-friendly prosthetic solutions. The low cost and simplicity of this design could make it a viable option for improving the quality of life and independence of transhumeral amputees in low-income countries, where access to advanced prosthetics is often limited.

CONCLUSION

In conclusion, this study highlights the potential for indigenous, low-cost prosthetic solutions to address the unmet needs of transhumeral amputees, particularly in underserved populations. By improving both functionality and psychological satisfaction, the proposed externally powered elbow unit can help to enhance the autonomy and quality of life for individuals with transhumeral amputations in resource-constrained settings.

Declaration by Authors
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REFERENCES

1. Ziegler-Graham K, MacKenzie EJ, Ephraim PL, Travison TG, Brookmeyer R. Estimating the prevalence of limb loss in the United States: 2005 to 2050. Arch Phys Med Rehabil. 2008;89(3):422e429.
2. Maduri P, Akhondi H. Upper Limb Amputation. [Updated 2023 Aug 8]. In: StatPearls Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK540962.
3. Sarah N. Pierrie, MD, R. Glenn Gaston, MD, Bryan J. Loeffler, MD, Current Concepts in Upper-Extremity Amputation, J Hand Surg Am., Vol. 43, July 2018.
4. Sandra L. Hubbard Winkler. Upper limb amputation and prosthetics epidemiology, evidence, and outcomes.
5. Department of Veteran Affairs, Department of Defense. VA/ DoD Evidence-Based Clinical Practice Guideline for the Management of Upper Extremity Amputation Rehabilitation. Washington D.C.; 2014.
6. Fryer C. M., Michael J. W., Upper-Limb Prosthetics: Body-Powered Components, Chapter 6A - Atlas of Limb Prosthetics: Surgical, Prosthetic, and Rehabilitation Principles.
7. Gates D. H., Walters L. S., Cowley J., Wilken J.M., Resnik L., Range of Motion Requirements for Upper-Limb Activities of Daily Living, American Journal of Occupational Therapy, 2016 Jan-Feb; 70(1): 7001350010p1–7001350010p10.
8. Ankit Kumar Ray, Yashika Kumar. Innovative modified passive functional shoulder prosthesis incorporating a double-axis hinge shoulder joint with servo motor for shoulder disarticulation patient. Int J Health Sci Res. 2024; 14(11):159-165. DOI: https://doi.org/10.52403/ijhsr.20241116.

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